Claims

[c1] A thick film heater comprising

a target object to be heated, wherein said target object is located in an environment of ambient temperatures significantly below 0 ° C;

a heating element consisting of an electrically thick film resistive circuit applied directly to a surface of said target object; and

wherein said electrically thick film resistive circuit is polymer based.

[c2] The thick film heater of claim 1 wherein said target object is designed to operate at temperatures below -75 ° C.

[c3] The thick film heater of claim 2 wherein said target object is designed to operate at temperatures below -150 ° C.

[c4] The thick film heater of claim 1 wherein said heating element is capable of heat flux at least as great as 200 watts per square inch.

[c5] The thick film heater of claim 1 wherein said target object is non-ferrous.

[c6] The thick film heater of claim 5 wherein said target object is aluminum.

[c7] The thick film heater of claim 5 wherein said target object is copper.

[c8] The thick film heater of claim 5 wherein said target object is ceramic.

[c9] The thick film heater of claim 1 wherein said target object is a high-expansion steel.

[c10] The thick film heater of claim 1 wherein said heating element further comprises a dielectric layer disposed between said target object and said electrically resistive circuit.

[c11] The thick film heater of claim 10 wherein said heating element further comprises a second dielectric layer disposed over said electrically resistive circuit, away from said target object.

[c12] The thick film heater of claim 10 wherein said dielectric layer consists of a

metal oxide .

[c13] The thick film heater of claim 12 wherein said metal oxide is selected from the group consisting of TiO2, SiO2, and Al2O3.

[c14] A method of manufacturing a thick film heater comprising a heating element applied directly to a surface of a target object, the method comprising the steps of:

applying the heating element, comprising a thick film resistive circuit directly to the surface of the target object, wherein the thick film resistive circuit is made of a polymer-based ink;

curing the heating element at a temperature in excess of 150 ° C for a period of time in excess of thirty minutes; and

sealing the heating element with a dielectric layer.

[c15] The method of claim 14 further comprising a plurality of said curing steps, wherein at least one of said curing steps occurs at a temperature in excess of 150 ° C for a period of time in excess of thirty minutes.

[c16] The method of claim 14 further comprising the step of preparing the surface of the target object with a lower dielectric layer, and wherein the heating element in said applying layer is applied over the lower dielectric layer.

[c17] The method of claim 14 wherein said curing step occurs at a temperature of 200 ° C or greater.

[c18] The method of claim 14 wherein said curing step occurs for a period of two hours or longer.

[c19] The method of claim 14 wherein the heating element is designed to operate at greater than 15 W/cm^2 .

[c20] The method of claim 14 wherein the target object is non-ferrous.

[c21] The method of claim 20 wherein the target object is aluminum.

[c22] The method of claim 19 wherein the target object is copper.

[c23] The method of claim 20 wherein the target object is ceramic.

[c24] The method of claim 13 wherein the target object is high-expansion steel.

[c25] The method of claim 13 wherein the polymer base of the thick film resistive circuit is an epoxy.

[c26] The method of claim 24 wherein the polymer-based ink contains silver particles.